DOCUMENT RESUME

ED 243 822 SP 024 192

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TITLE Effects of Arm Ergometry Exercise on the Reaction, Movement and Response Times of the Lower Extremities.
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PUB DATE [83]
NOTE 14p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Adults; *Exercise Physiology; *Fatigue (Biology); Heart Rate; Males; *Motor Reactions; Muscular Strength; Physical Activity Level; *Reaction Time
IDENTIFIERS *Arms; *Legs

ABSTRACT

A study determined the effects of fatigue produced in the upper extremities on the reaction time, movement time, and response time of the lower extremities in 30 male subjects, 19-25 years old. Each subject participated in a 10 trial practice session one day prior to the experiment and immediately preceding the pre-test. The pre-test consisted of four trials with 15 seconds between each trial. One minute after the termination of the progressive arm ergometry exercise, post-test, recovery 1, 2, and 3 reaction time treatments were administered. A single group design ANOVA with repeated measures indicated that reaction, movement, and response times were significantly faster during the pre-test than during the post-test, recovery 1, 2, or 3, while there were no significant differences between mean times for post-test, recovery 1, 2, or 3. The ANOVA for trial effects during the third trial were significantly faster than during the first trial, while there were no significant differences between other trials. It was concluded that heavy physical fatigue produced in the upper extremities transferred to the lower extremities and significantly impaired the whole body reaction time, movement time, and response time and that this deteriorative effect remained during acute recovery. (Author/JMK)

EFFECTS OF ARM ERGOMETRY EXERCISE ON THE REACTION,

MOVEMENT AND RESPONSE TIMES OF THE LOWER EXTREMITIES

by

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*Special acknowledgement is given to Mr. Mansour Sayah for his assistance with this research.

ABSTRACT

EFFECTS OF ARM ERGOMETRY EXERCISE ON THE REACTION, MOVEMENT AND RESPONSE TIMES OF THE LOWER EXTREMITIES

This investigation was designed to determine the effects of fatigue produced in the upper extremities on the reaction time, movement time and response time of the lower extremities. Subjects included 30 male volunteers ranging in age from 19 to 25 years. Each subject participated in a 10 trial practice session one day prior to the experiment and immediately preceding the pre-test in order to reinforce learning and reduce warm-up decriment. The pre-test consisted of four trials with 15 seconds between each trial. One minute after the termination of the progressive arm ergometry exercise (endpoint heart rate = 180), post-test, recovery 1, 2 and 3 reaction time treatments were administered. A single group design ANOVA with repeated measures indicated that reaction, movement and response times were significantly ($p < .01$) faster during the pre-test than during the post-test, recovery 1,2 or 3, while there were no significant differences between mean times for the post-test, recovery 1, 2 or 3. The ANOVA for trial effects indicated that the mean reaction, movement and response times during the third trial were significantly ($p < .01$) faster than during the first trial while there were no significant differences between the second, third and fourth trials or the first, second and fourth trials. The author concluded that heavy physical fatigue produced in the upper extremities transferred to the lower extremities and significantly impaired the whole body reaction time, movement time and response time and that this deteriorative effect remained during acute recovery.

In several sports including boxing the upper extremities become very fatigued. The effect of this upper extremities fatigue on the reaction time, movement time, and response time of the lower extremities would be of interest to coaches and athletes since constant footwork is an important aspect of many sports.

Numerous investigations have been conducted to identify factors which impair reaction, movement and response times (1,4,6,7,9,10,12). Fatigue, which is produced by exhaustive muscular work, has been identified as an impairment to motor performance. Experimental evidence suggests that local muscular fatigue increases reaction, movement and response times in the exercised limb; however, evidence is lacking to identify the effects of local muscular fatigue on the reaction, movement and response time of the non-exercising limbs. The purpose of this study was to determine the effects of fatigue produced in the upper extremities on the reaction, movement and response time of the lower extremities.

METHODS

Subjects for the study included 30 male volunteers ranging in age from 19 to 25 years. All subjects received a medical clearance for participation in the study and signed informed consent was obtained.

Reaction and movement time were recorded using a T.K.K. whole body reaction timer model 1264. The simple reaction and movement time task involved responding to a visual stimulus and jumping with both feet from one switchmat to another positioned 50 cm directly in front of the subject. The subjects were given a ready command immediately before the stimulus button was pressed. The 1264 reaction timer automatically varied the pre-stimulus interval. The 1264 also provided a digital record of reaction and movement time in milliseconds.

The subjects participated in a 10 trial task one day prior to the experiment in order to acclimate them with the equipment and procedures and to allow adequate learning of the task. A 10 trial practice session immediately preceded the pre-test in order to reinforce learning and to reduce the possibility of a warm-up decriment.

The pre-test consisted of four trials with 15-second intervals between trials. After pre-test measurements were recorded the subjects performed a heart rate limited (HR=180) arm ergometer exercise on a Monarch Model 880 Rehab Trainer. The subjects were seated with the legs crossed and bound. The arm ergometer exercise consisted of consecutive three minute workbouts, beginning at 0 kgm/min and sequentially increased every three minutes by 150 kgm/min until the subject reached and maintained a heart rate of 180 bpm for 15 seconds. A cranking rate of 50 revolutions per minute was paced by an electronic metronome. Heart rate was monitored using a Quinton Cardiotachometer Model #609.

Immediately following the termination of the arm ergometer exercise, a one minute rest interval was given during which the subject was moved into position for the post-test reaction, movement and response time trials. Again four trials were given with 15 second intervals between trials. Recovery effects were monitored by administering three, four trial recovery test with three minute rest intervals between recovery treatments.

RESULTS

The data were analyzed using a single group design ANOVA with repeated measures. When F-ratios indicated that significant differences existed, Duncan's New Multiple Range test was used to locate the sources of the significant differences. All statistical values were tested for significance at the $\alpha = .05$ level.

Significant F-ratios ($p < .01$) for treatment effects were obtained for reaction, movement and response times. The Duncan's post hoc analysis indicated that reaction, movement and response times were significantly faster during the pre-test than during the post-test, recovery 1, 2 or 3, while there were no significant differences between mean times for the post-tests recovery 1, 2 or 3 (Figures 1 and 2).

Significant ($p < .01$) F-ratios for trial effects were also obtained for reaction, movement and response times. The Duncan's post hoc analysis indicated that the reaction, movement and response time during the third trial was significantly faster than during the first trial, while there were no significant differences between the second, third and fourth trials, or the first, second and fourth trials (Figures 3 and 4).

The treatment by trial interaction effect for all variables provided non-significant ($p > .05$) F-ratios. This non-significant interaction signifies that the differences observed among the trial and treatment effects hold true with repeated sampling.

DISCUSSION

The results of the current investigation indicated that fatiguing arm ergometry work (HR=180) caused a significant ($p < .01$) decriment in whole body reaction, movement and response times. These findings were indirectly in agreement with the findings of Alderman (1), Carron (4), Bender and McGlynn (3), and Williams and Singer (14). These authors studied the effects of localized fatigue on performance and reported significant decrements in performance following fatiguing exercises.

In an early study Alderman (1) used arm ergometry exercise as a fatiguing task and reported a significant decriment in performance in motor coordination tasks emphasizing both speed (Rho test) and accuracy (pursuit rotor) of arm movements.

The findings of the current study conflicted with the findings of Elbel (5), Meyers, Zimmerli, Farr and Baschnagel (11), Phillips (12), and Welch (13). These conflicting findings could have been caused because the fatiguing tasks employed in these studies required submaximal levels of physiological work. In essence the subjects were being warmed-up rather than fatigued.

Most of the previously mentioned studies were designed to evaluate the effects of localized fatigue on the performance of the specific muscle groups involved in the fatiguing task; however, Welch (13) studied the possibility of transfer of fatigue from the working legs to the non-working arms and reported an absence of fatigue transfer from heavy leg work to coordination tasks using the arms.

There was evidence that the workload used in the current experiment was heavy and produced fatigue. Several clinical signs of fatigue including sweating, labored breathing, as well as inability to maintain the initial rate of cranking and oral complaint of local muscular fatigue were observed during the last minutes of exercise. The current author has previously reported that the mean maximum HR during arm work in the sitting position of a group of college males was 182 bpm (8). Since all subjects in the current study reached a heart rate of 180, the researcher assumed that the work intensity was very near maximum levels.

The detrimental effect of fatigue on performance is probably the result of the accumulation of the usual by-products from the biochemical reactions which occur during heavy fatiguing physical exercise. Asmussen and Nielson have reported that work requiring fewer muscles to achieve a given rate of oxygen uptake is accompanied by higher lactate levels than when greater muscle mass is involved. Thus, arm work would be expected to produce higher lactate levels than comparable work using the legs, increasing the chance of possible detrimental effects on performance.

The results of the current study also indicated that there were significant differences ($p < .01$) between the first and third trials for reaction, movement and response times, while there were no significant differences ($p > .01$) between the first, second and fourth or the second, third and fourth trials. Figures 3 and 4 show post-test, recovery 1, 2 and 3 data only since there was no trend among pre-test trials. For all variables, the third trial was significantly faster than the first trial. These differences between trials persisted throughout the post-test and recovery 1, 2 and 3. Perhaps the differences between trials were due to the posture during recovery. Since the subjects were in a sitting position during the recovery period and during the stress test, this would cause a pooling of blood in the lower extremities trapping high levels of lactate in the muscles. Each performance trial was followed by a 15 second preparation interval, therefore the subjects had been actively involved in trials one and two and standing for 45 seconds before trial three. The active participation in trials one and two and the elapsed time would allow the body to adapt to postural changes and would increase venous return to the heart which would assist in removing some of the trapped lactate. These findings seem to suggest that in sports such as boxing where upper extremities fatigue is eminent, the participant should maintain an erect posture and lift the legs during the rest interval between rounds. Based on the data obtained from the current investigation the researcher concluded that heavy physical fatigue produced in the upper extremities transferred to the lower extremities and significantly impaired the whole body reaction time, movement time and response time and that this deteriorative effect remained during acute recovery.

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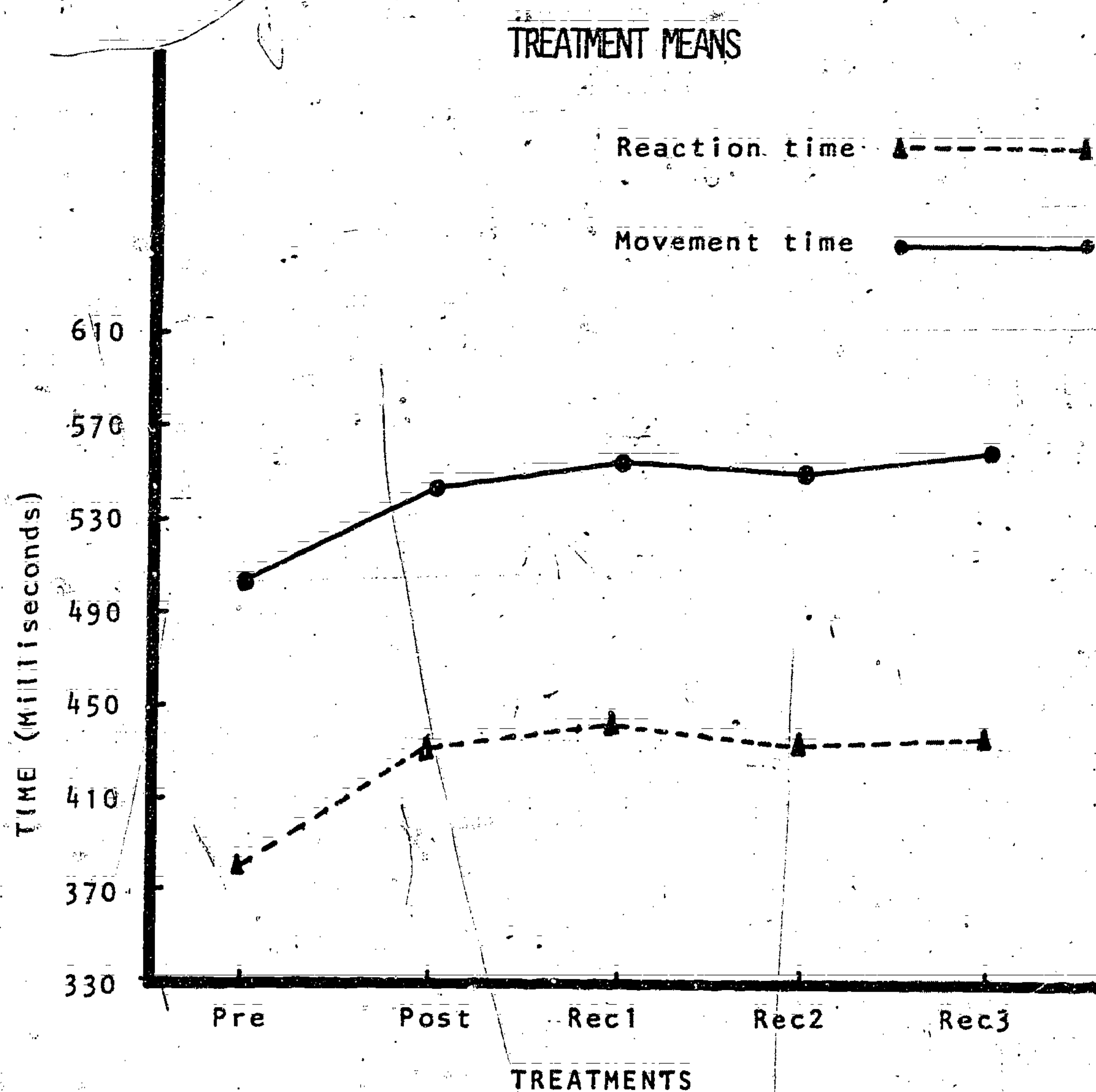

Figure 1: Mean Reaction and Movement Time Across Treatments

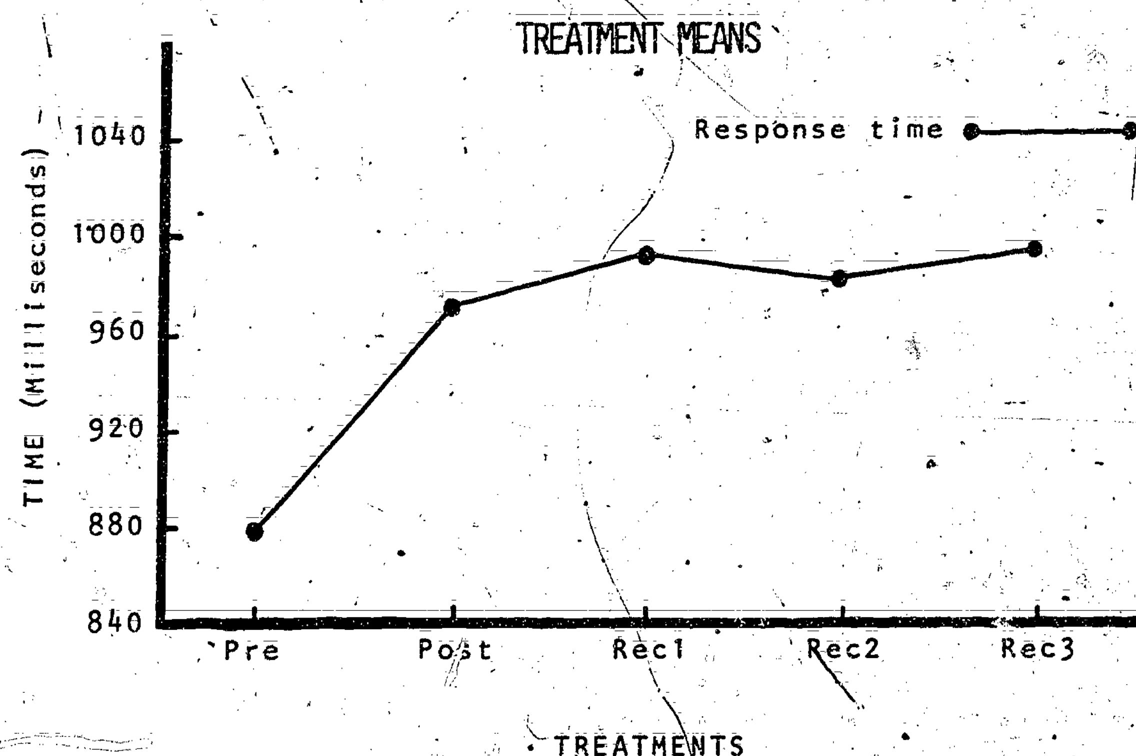

Figure 2: Mean Response Time Across Treatments

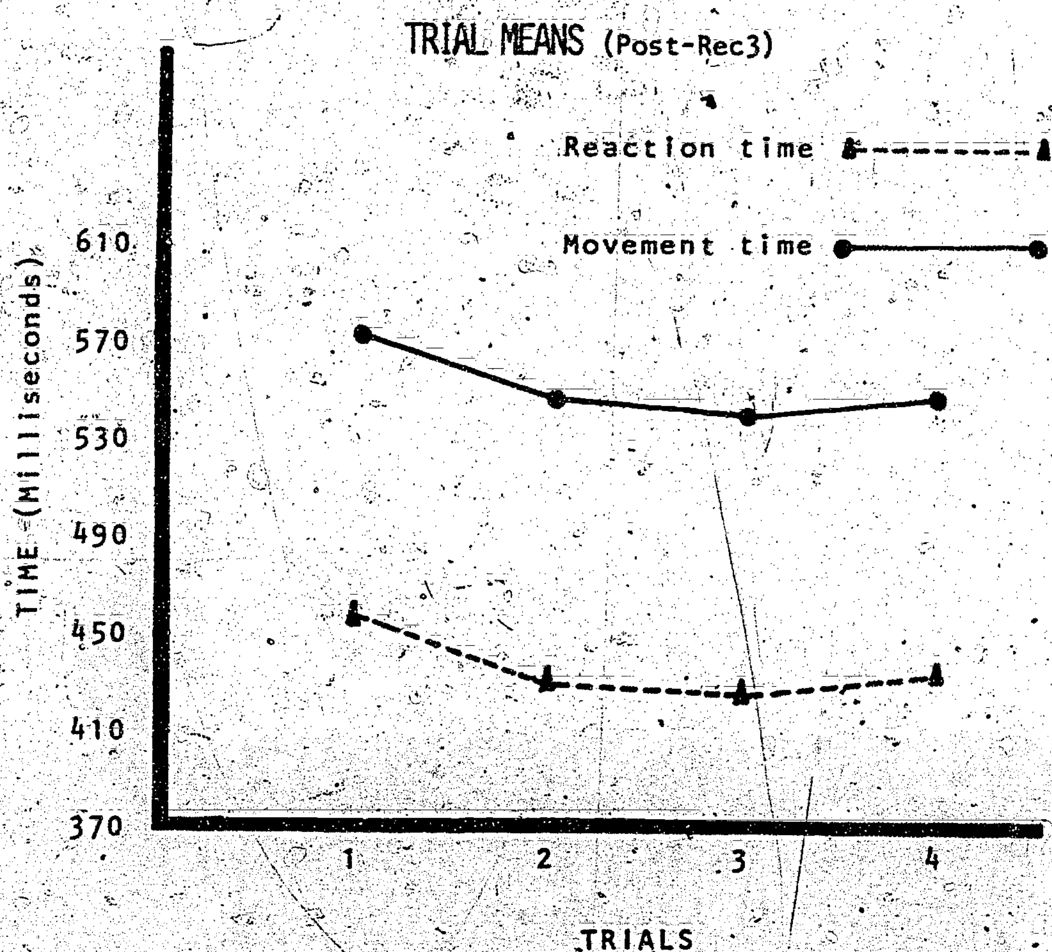

Figure 3: Mean Reaction and Movement Time Across Trials

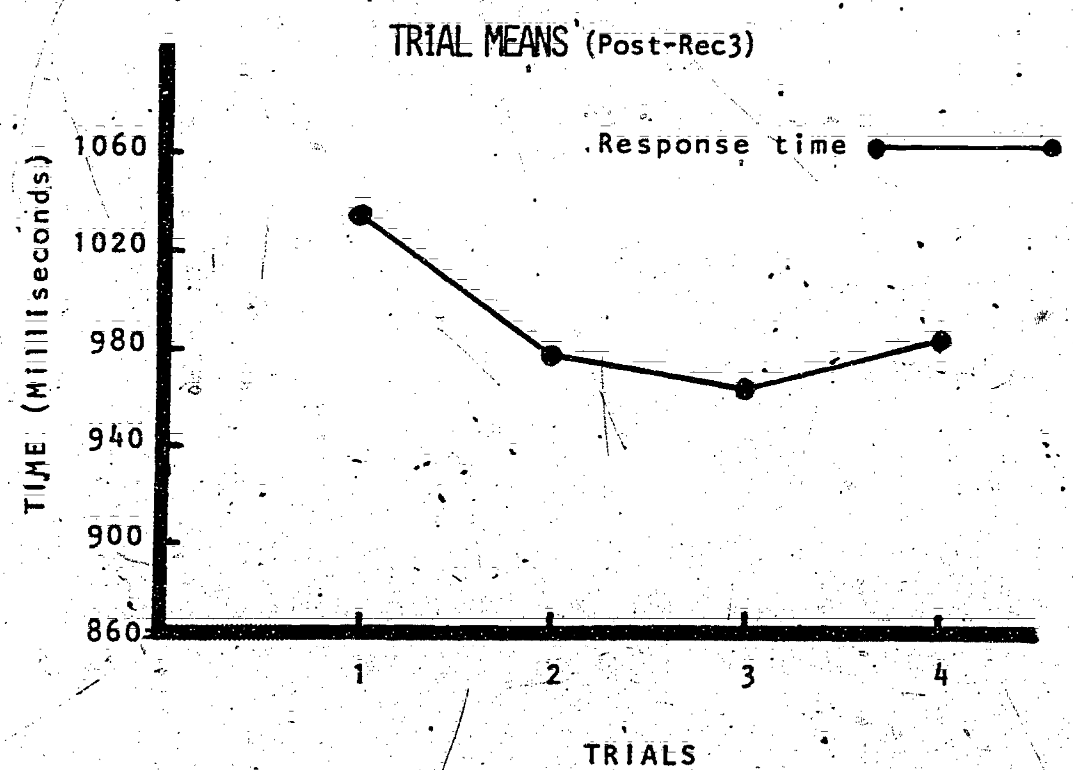

Figure 4: Mean Response Time Across Trials